Scalable and Robust Integrated Quantum Communication System

1. Position in the program

This project is actively engaged in the R&D of quantum network architecture & protocols to enable quantum communication between quantum computers (QCs). By connecting QCs through quantum communication, the overall computational capability is determined by the computing power of each QC and the communication system and infrastructure that links them. To realize this system and extract its performance fully, it is necessary to develop multifaceted mechanisms that span quantum/classical and hardware/software domains, as well as conduct R&D on repeaters, interface devices, and connection devices. Through the creation of a quantum network system that realizes distributed QCs, this project contributes to the achievement of Goal 6.

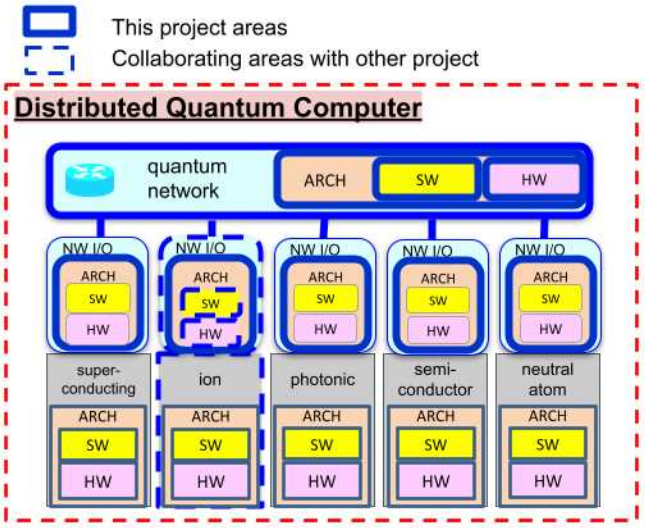

Fig 1. Research area of this project

2. Overview of the R&D and the Challenges

This project is characterized by prototype development and demonstrations of principles & technologies in the QC network testbed, as well as a global strategy utilizing global standardization. As the implementation of QCs began in the 2010s, the 2020s are expected to begin the comprehensive and integrated implementation of quantum networks, playing a crucial role in the R&D of quantum information. We focus on four R&D areas, utilizing the testbed:

1. Quantum network architecture and protocols
2. Quantum optical communication technologies
3. Quantum memory technologies for extracting full communication performance
4. Applications feasible on quantum computer networks

These areas not only generate individual achievements but also interact with each other to create practical outcomes by aiming for the concrete realization of quantum networks. As quantum networks have not yet been realized and the necessary functionalities and challenges are not clear, utilizing the testbed enables the early detection of unpredictable deficiencies and issues such as perception gap among different research fields and required technologies.

Furthermore, this project will engage in activities within international standardization organizations such as IETF (Internet Engineering Task Force) and IRTF (Internet Research Task Force). Through these activities, we will propose standards for quantum network architecture, protocols, and signal input/output. By publishing specifications for quantum communication systems, we aim to contribute to determining the global direction of R&D. Furthermore, our goal is to involve R&D efforts from around the world into the framework of this project.

3. Future plans

As of June 2023, we have established the transmitter for one node of the quantum network in Kawasaki City (Fig. 2). Our focus will be on improving this node, expanding to multiple nodes, and achieving routing connections through repeaters. We will also work towards the realization of a networked system and demonstrate a quantum communication system connecting QCs. Additionally, we aim to extend distance and numbers of nodes to demonstrate a data center-scale quantum network (Fig. 3).

Fig 2. Quantum optical system in testbed at Kawasaki City
1-terminal node is constructed on the optical table

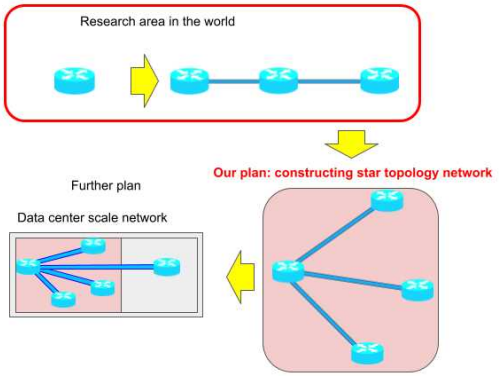

Fig 3. Plan for development of quantum computer network